Information Processing in Children with ADHD

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ABSTRACT

Attention Deficit Hyperactivity Disorder, also referred to as ADHD, is becoming one of the most commonly diagnosed disorders in mental health facilities and school-based settings. Treatment modalities such as medication management, Independent Educational Plans (IEP’s), and counseling interventions are being utilized to better understand this disorder and help those that are diagnosed achieve a level of functioning that meets their daily goals. However, while the aforementioned treatment modalities have proven successful, there remains some resistance on part of those diagnosed in adulthood with respect to accepting initial diagnosis and a willingness to comply with treatment. Children with this diagnosis are often said to exhibit difficulty processing information and completing tasks in a timely fashion. This paper seeks to explore the effects of ADHD in the brain and its relationship to information processing and human learning, more specifically in the classroom.
BRIEF OVERVIEW AND HISTORY OF ADHD

According to *Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment* (2015), the history of Attention Deficit Hyperactivity Disorder dates back to the 1700’s. A description in a medical textbook by Melchior Adam Weikard described symptoms of this disorder such as: inattentiveness, distractibility, lack of persistence, exhibiting impulsivity, and presenting in an overly active demeanor (Barkley, 2015). Such a description continues to be utilized today when describing symptoms of ADHD. In the 1700’s, symptoms of ADHD applied to men and women of all ages, whereas today there is a more detailed description, subtypes, levels of severity, and careful attention placed on age of onset. As of late, a large portion of studies have shed light on the effectiveness of medications used for children, as well as the use of psychoeducation within families, educators, and administrative staff in the schools. One of the areas that deserves more attention, with respect to ADHD would be to better understand the affects that diagnosis and treatment have on adolescents in a school setting.

In an article written by Skogli, Teicher, Anderson, Hovik, and Oie (2013), ADHD was reviewed in terms of gender differences, symptoms, and executive functions. The article addresses how ADHD is diagnosed more in males than females, further suggesting the differences in expression of the disorder as reason for possible underdiagnosing in adolescent girls. The study consisted of an experimental design with 37 females, 43 males, and two healthy control groups with 18 females and 32 males. All participants were adolescents, ages 8-17, with the first two groups formally diagnosed with ADHD. In addition to an impaired executive function, as per parent-report, and more specifically, scales and ratings. The results show a self-report of high anxiety in adolescent females with ADHD and rule-breaking behavior in
adolescent males with ADHD, when compared with the healthy control groups, thus highlighting the significance of self-report scales on the awareness of internalizing problems.

**ADHD AND THE BRAIN**

According to the National Institute of Mental Health (NIMH), using a scanning test called functional magnetic resonance imaging (fMRI), doctors have found that the frontal cortex, in area of the brain responsible for attention, reason, memory, planning, and inhibition, appears thinner and matures slower in children with ADHD. NIMH also found that the motor cortex, an area of the brain that controls movement, grew much faster than normal in a child with ADHD (Subhulakshmi, "Diagnosis of ADHD using Brain Imaging Technique: A Survey," 2013). This could explain why hyperactive children have a constant need to be moving, even at a young age. Below is a picture illustrating an EEG scan of a “normal” child’s brain compared to a child with ADHD. This scan highlights areas of activity within the frontal lobe:

("qEEG Brain Map", 2015)
It has also been discovered that children with ADHD have less gray matter and lower brain volume than children without ADHD, which goes to explain a child with ADHD’s impulsivity and struggle to concentrate and remain on task ("Attention Deficit Hyperactivity Disorder," 2015). A new technique called diffusion tensor imaging (DTI) lets scientists look at the white matter in children's brains in more detail. White matter consists of axons (nerve fibers) covered by myelin sheaths. DTI lets us look at the nerve pathways between different areas of the brain. Using DTI, it was found that there are abnormalities in the fiber pathways in the frontal cortex, basal ganglia, brainstem, and cerebellum. These areas are involved in attention, impulsive behavior, inhibition, and motor activity. (Subhulakshmi, n.d.) Findings have suggested that specific brain circuits that connect different areas of the brain may be altered in people with ADHD (Kensington, "The ADHD Brain," n.d.). It is not surprising, therefore, to find that people with ADHD often have problems with regulating attention, behavior, and learning.

Research has shown that ADHD does not equate to a different brain structure, just a difference in terms of brain function. Different areas of the brain communicate by sending signals via neurotransmitters. Dopamine and norepinephrine are neurotransmitters that help send messages between areas of brain associated with attention and motivation. The brain of a person with ADHD may have less of these chemicals available, which may explain why someone with ADHD has difficulty paying attention or performing repetitive tasks.

Typically, the brain consists of two sides that work together in a different yet complementary fashion, with each hemisphere having its own specialties:

LEFT BRAIN FUNCTIONS

RIGHT BRAIN FUNCTIONS
Studies uncover information comparing the brains of children with ADHD, to those who do not have ADHD. One study, in particular, looked at children with and without ADHD over a 10-year period. At various ages, children's brains were scanned using magnetic resonance imaging (MRI). The researchers found that the brains of boys and girls with ADHD were 3% to 4% smaller than the brains of children without ADHD; “also children with more severe ADHD symptoms had smaller frontal lobes, temporal grey matter, caudate nucleus, and cerebellum. These brain regions are involved in concentration, impulse control, inhibition, and motor activity, which are all problem areas for children with ADHD. The course of brain development in children with and without ADHD was similar. This suggests that changes in the brain happen early in development” (Kensington, n.d.) .

When communication between the two sides of the brain breaks down, one side becomes dominate and the other falls behind in its activity and development. Overall brain function suffers, with detrimental effects, especially when discussing Attention Deficit Hyperactivity
Disorder, which is known to cause detriment to the right hemisphere, where social skills, communication, reading comprehension, and maintaining focus tend to dominate. (Otis, "Brain-based Treatments for ADHD – 8 Things a Parent Should Know," 2015)

**ADHD IN SCHOOLS**

In school settings, what a teacher observes and the child experiences can be two different things. For example, due to differences in brain function and lack of gray matter, teachers may observe a child with ADHD become irritable after experiencing noise brought on by classmates. The same child may begin an assignment and get “sidetracked,” causing them to start a different assignment, or may participate in a group activity and then, as time goes by, begin to “drift off” and cease participation. While the teacher observes this behavior, the child may be experiencing feelings of distractibility, which in turn makes it more difficult for the child to keep up academically with his or her peers.

In another instance, the teacher may notice a child interrupting or making comments at inappropriate times, irritating other children by talking during an otherwise quiet time, or having difficulty getting to the point when answering questions. Again, this seemingly uncontrollable impulsivity can result in the child feeling uncomfortable mainly because he or she is noticing their own differences when compared to their peers. In addition, the teacher may notice a child being argumentative and demanding to get the last word in, making it difficult for other children to make classroom presentations, instead insisting that they be the ones to talk. Many children with ADHD experience frustration and difficulty expressing themselves to others as well as feeling powerless with respect to filtering their language.
Teachers also notice times when children “space out” and may forget supplies or assignments for class or homework, forget teacher’s instructions, or may ask for directions to be repeated when it was evident that the child was listening during the classroom discussion. Below is an illustration of an active “typically functioning” brain alongside an active brain of an individual diagnosed with ADHD. In a typical brain neurons “fire off” with little to no interference while a brain with ADHD experiences complications and obstacles.

![NORMAL BRAIN vs ADHD BRAIN](image)

**TREATMENT AND ADHD**

When a child is taking stimulant medication for ADHD, the medication changes the level of a chemical in the brain called dopamine, which is a neurotransmitter that plays a critical role in attention and focus. This medication helps to increase the dopamine in their brain to an optimal level, a level that is considered to be comparable to that in the brain of a person who does not have ADHD (Miller & Child Mind Institute, "Will ADHD Medication Change My Child's Brain?," n.d.). Stimulant medications work by blocking the action of something called a dopamine transporter, a molecule that removes dopamine from the neural pathway (Lahey, "For..."
Changing the level of dopamine in the brain changes the way the brain functions while taking the medication. At the dosage that ADHD medications are prescribed, the level of dopamine is not high enough to produce euphoria and therefore are not considered addictive for children.

The effects of stimulant medications start and stop quickly because these medications are metabolized quickly. They do not stay in the body for an extended period of time. There are several different formulations of ADHD medications, each designed to last anywhere from about 4 hours (which is considered to be an “immediate release”) to 12 hours (which is considered to be a “delayed release”), therefore, the medications are essentially out of the child's system when he or she wakes up in the morning. Any possible side effects, such as loss of appetite or trouble sleeping, also cease when the child stops taking the medication.

As for long-term effects of stimulant use, it is stated that in over 50 years of using stimulant medications to counteract the symptoms of ADHD, and hundreds of studies, no negative effects of taking the medication over a period of years have been observed (Miller & Child Mind Institute, n.d.). In 2013 researchers compared the brains of children with ADHD before and after a year of treatment with stimulant medications (Lahey, n.d.). The studies showed an increase in the density of dopamine transporters—those molecules that take dopamine out of action—in the brain after treatment, which suggests that the increase of dopamine stimulated by the medication may have prompted the brain to develop more dopamine transmitters to clear it away. How long that change might last is not clear, as the level of transporters in the brain fluctuates. But it could result, researchers note in their conclusion, in the medication not working as well as it had to reduce symptoms over the long run (Lahey, n.d.). Questions continue to arise
about increasing dosage to accommodate growth and development in children. For many children the same dose (adjusted for growth) continues to work for many years, but for others the medication doesn't work as well after the first few months and needs to be increased for continued results.

While the dose increases are modest, they are not just a result of children growing. In an article covering ADHD and medication in *The Child Mind Institute* (2015), the researchers covered the largest long-term study of ADHD treatments called the MTA study (Multimodal Treatment Study of Children with ADHD), where in the first month of the study was devoted to titration—adjusting the dose until they had arrived at the optimal dose for each child. But over the 13 following months, many of the children had their dosage modified to continue to get the full benefit of the medication.

There continues to be a number of reasons behind medication management with respect to increasing, decreasing, or maintaining dosage. Doctors have cited the mature development of a child’s liver, assisting in their ability to metabolize medication at a faster rate, while other doctors believe that the external expectations placed on children. Expectations such as school, homework, classwork, and extracurricular responsibilities, result in increased pressure as well as an increased awareness with respect to effects of medication, more specifically the ability to maintain or obtain success with the associated dosage. In other words, children and parents oftentimes wonder if their current dosage can “keep up” with the elevated responsibilities. While some parents are in full agreement with medication, others are skeptical and even resist the need for medication.
Natural treatment methods, while less common than medication, can be effective for some people. Outcome studies show remarkable success with drug-free treatment for children with ADHD. In a recent study published in the International Journal of Adolescent Medical Health, children were given twelve weeks of neurological rehabilitation designed to improve the connection between right and left sides of the brain and increase the activity of the right hemisphere of the brain. All children were assessed with the Wechsler Individualized Achievement Test and the Brown Attention Deficit Disorder Scale before and after intervention. All of the children rated as having ADD/ADHD on the Brown scale before the intervention. After twelve weeks of neurological remediation, children showed greater than two years improvement in all but one of the WIAT subsets (Otis, 2015).

Drug-free treatment generally involves strengthening connections between the two sides of the brain, and then exercising the weak side. With all that has been learned about brain science and ADHD over the last decade, the options available to parents to support their kids have expanded significantly. When parents approach their child’s ADHD with a plan that includes a combination of training, treatments and accommodations, the outcomes for their child and family are significantly improved.

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